IEEE STANDARDS ASSOCIATION

IEEE P2716: IEEE Guide for the characterization of the effectiveness of printed circuit board level shielding

Single Reverb Room

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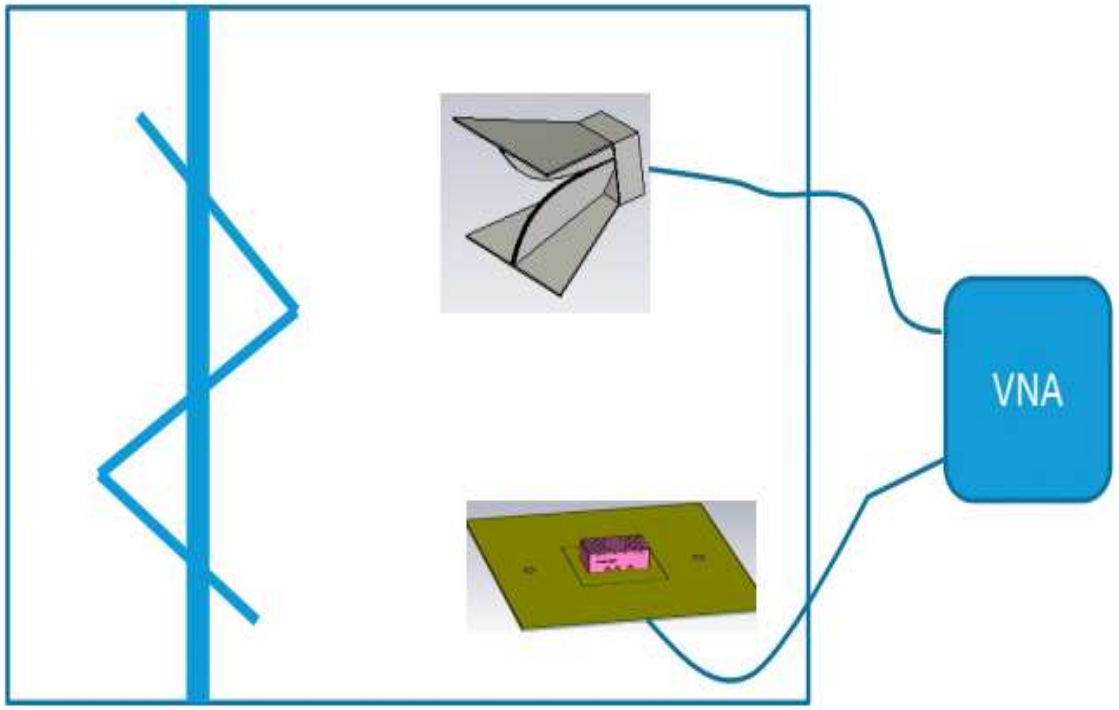
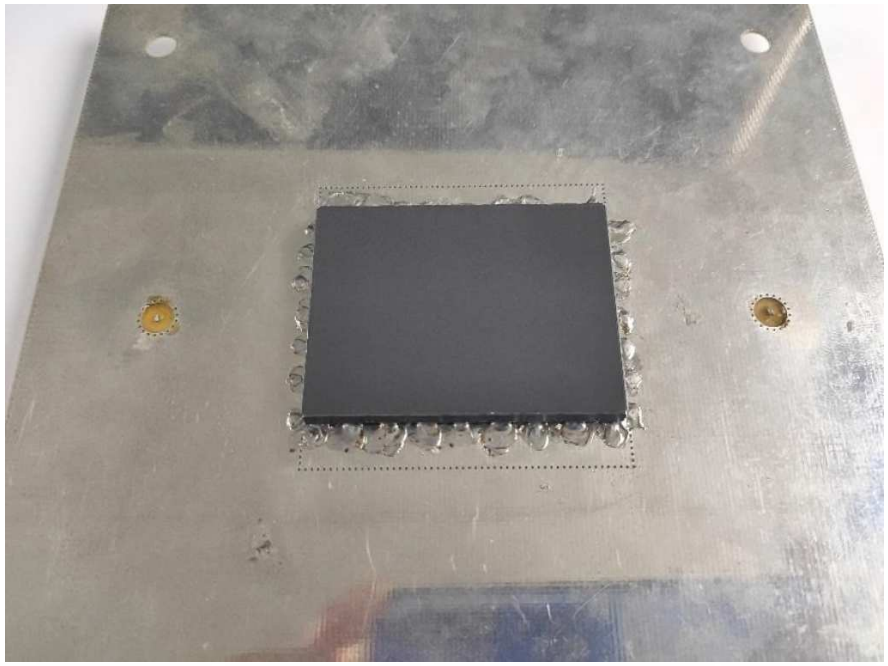
Laird Measurement setup



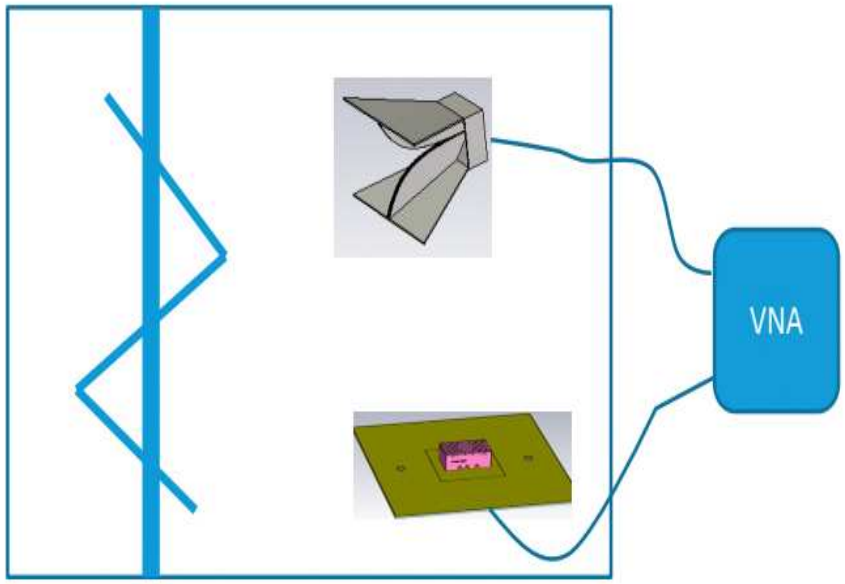
Sample test jig

Laird SE test jig - open

Laird SE test jig – with shield

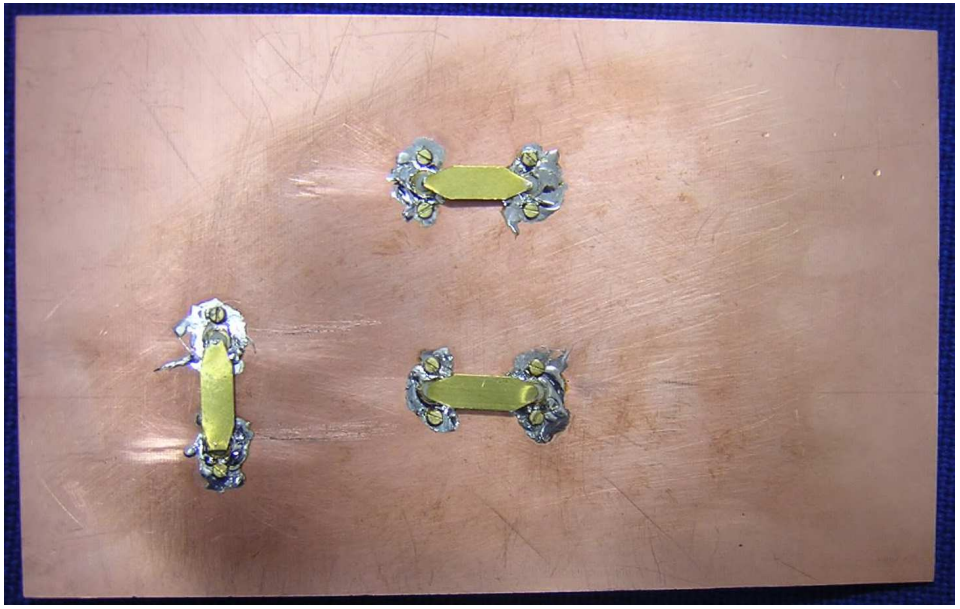


UoY Measurement setup

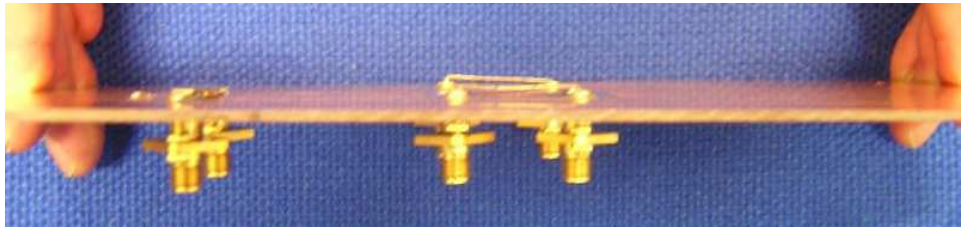


UoY Sample test jig 1

Top view - no shield

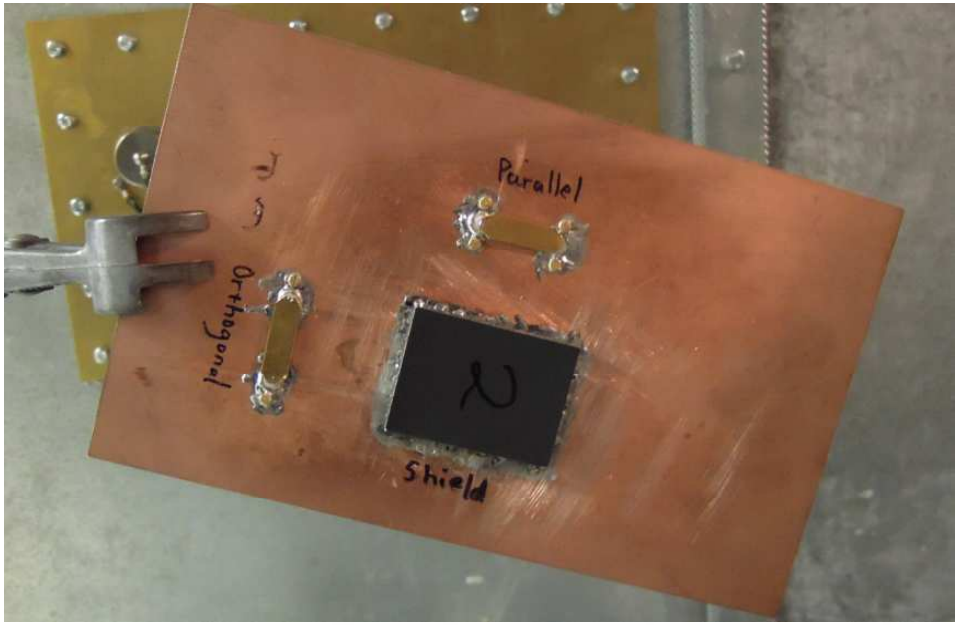


Side view- no shield

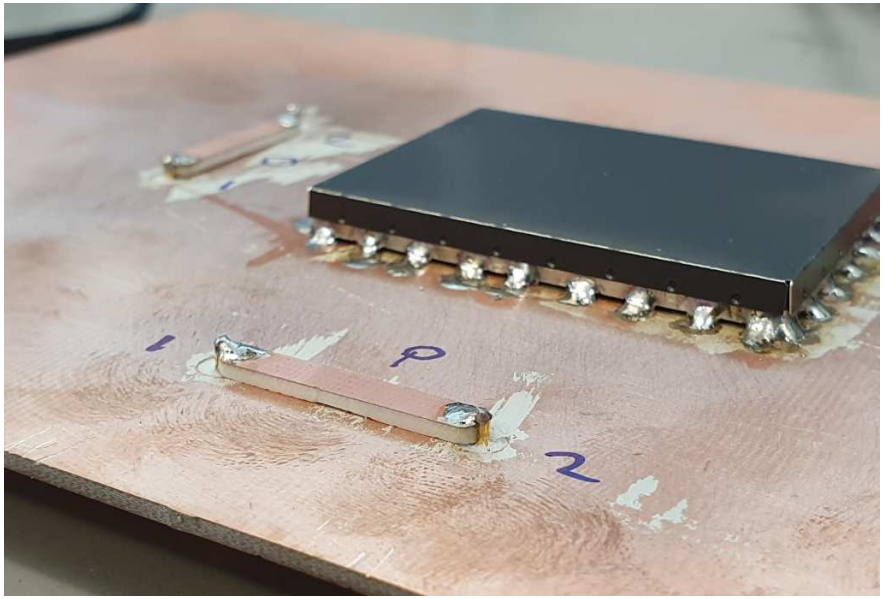


Sample test jig

UoY SE test jig 1 – with shield



UoY SE test jig 2 – with shield

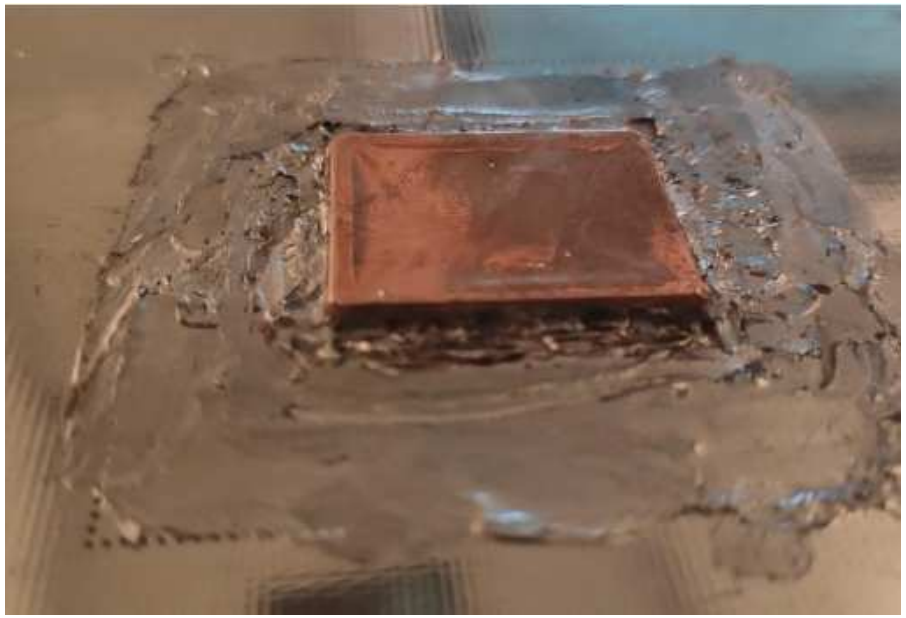


Definitions of SE

- IEEE 299
  - **shielding effectiveness (SE):** The ratio of the signal received (from a transmitter) without the shield, to the signal received inside the shield; the insertion loss when the shield is placed between the transmitting antenna and the receiving antenna.
- IEC 6100-4-21 standard gives a definition:
  - $SE = \frac{\langle P_u \rangle}{\langle P_s \rangle}$ or in decibels $SE = 10\log_{10}\left(\frac{\langle P_u \rangle}{\langle P_s \rangle}\right)$ dB
  - Where P_u is the power coupled to a measurement antenna in the absence of a shield (unshielded) and P_s is the power coupled to a measurement antenna inside a shield (shielded) and $\langle x \rangle$ indicates that x is averaged over a number of measurements with different boundary conditions (stirrer positions, antenna positions, frequencies etc.).

Dynamic range

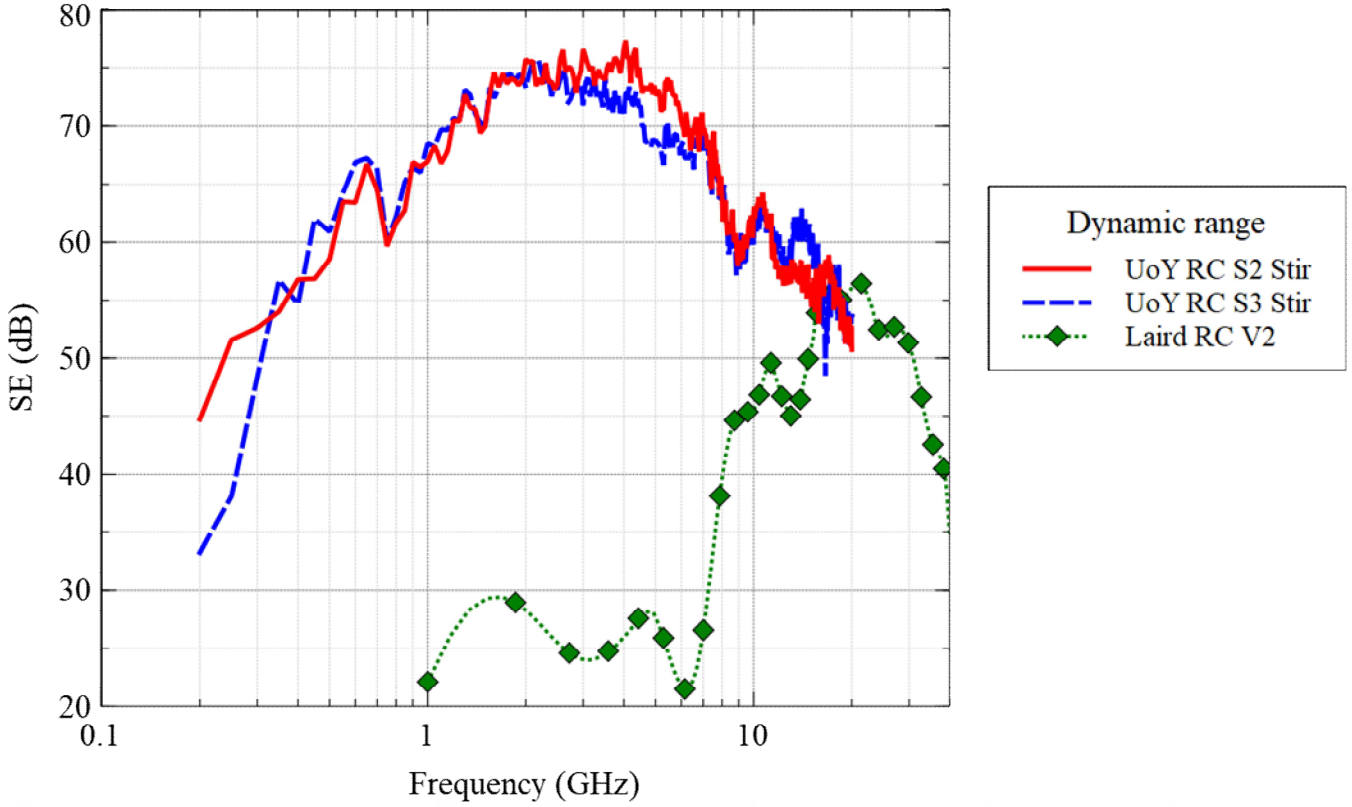
Laird Dynamic range test



Dynamic range – Measure SE with:

- Laird
  - Solid copper shield over track
- UoY
  - Disconnect jig and terminate cable with matched load
  - Antenna remains connected

Dynamic range for Reverb method



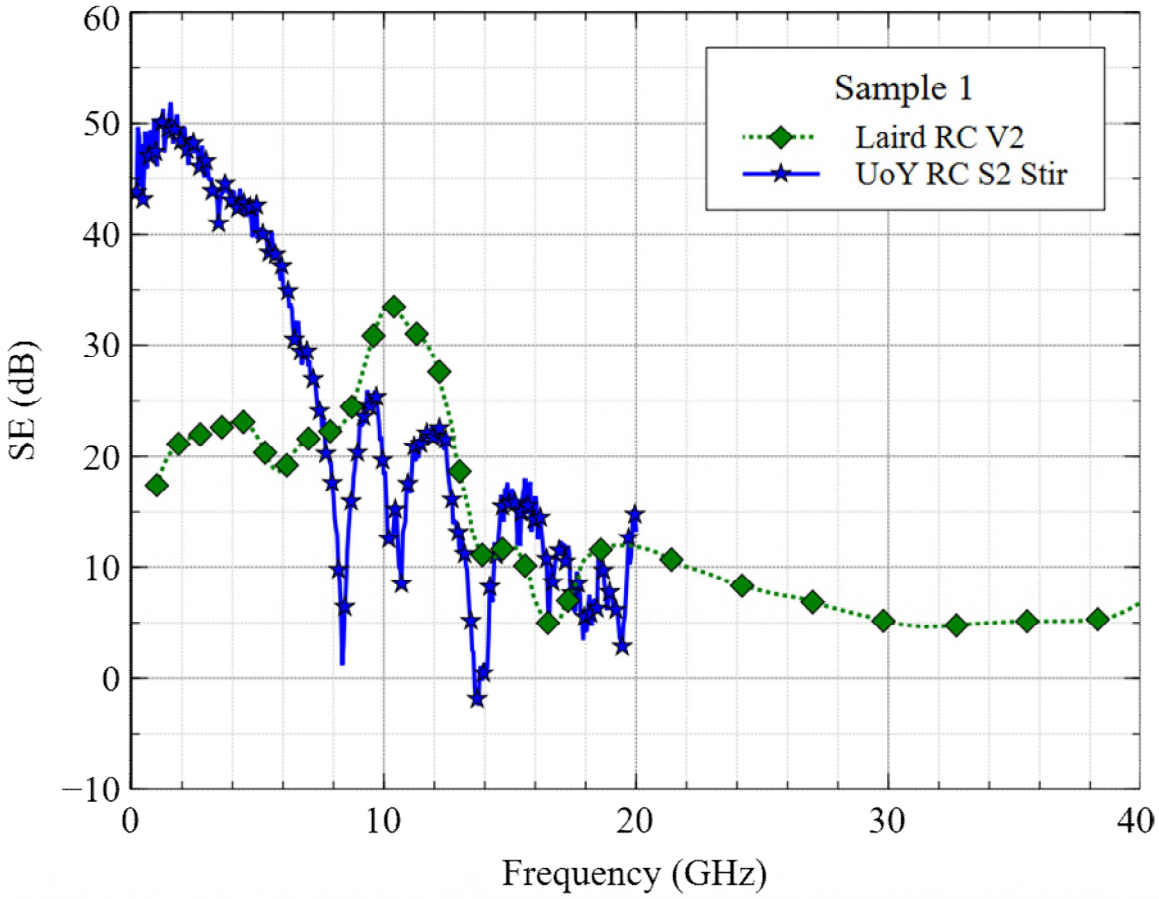
UoY :

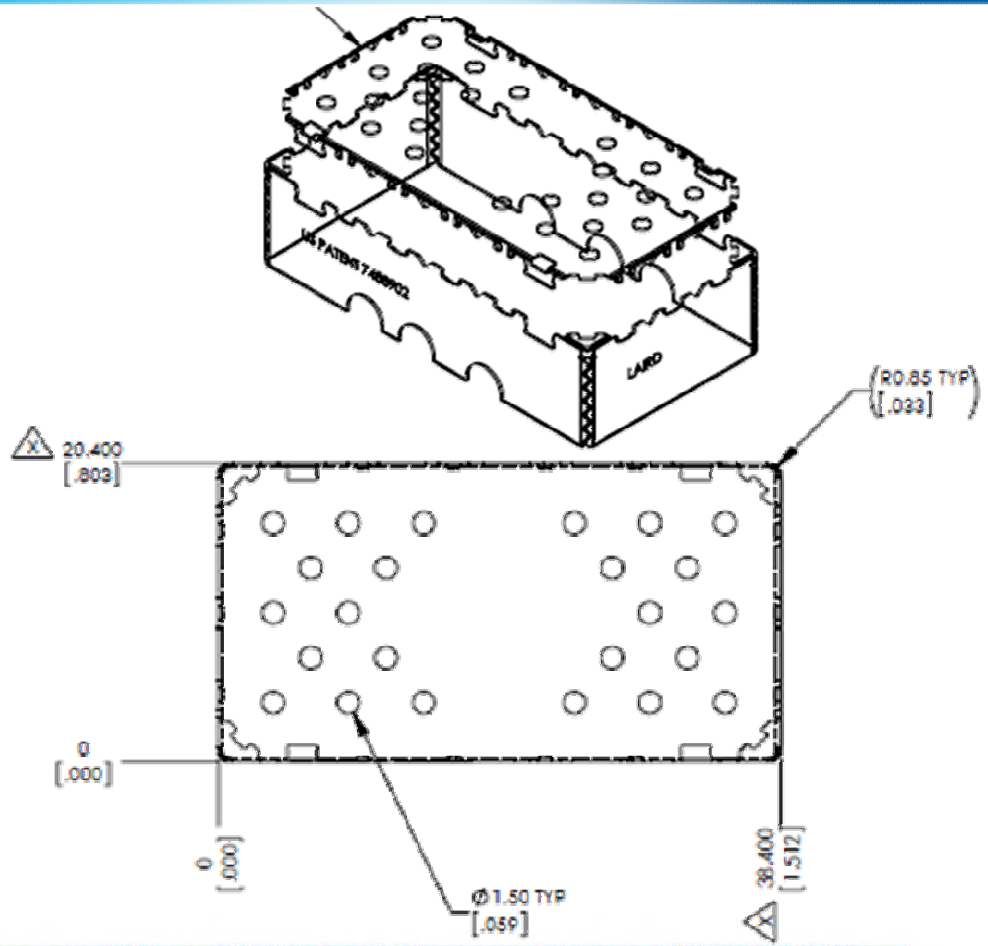
4.7m×3.0m×2.37m $(L \times W \times H)$

100 Stirrer positions

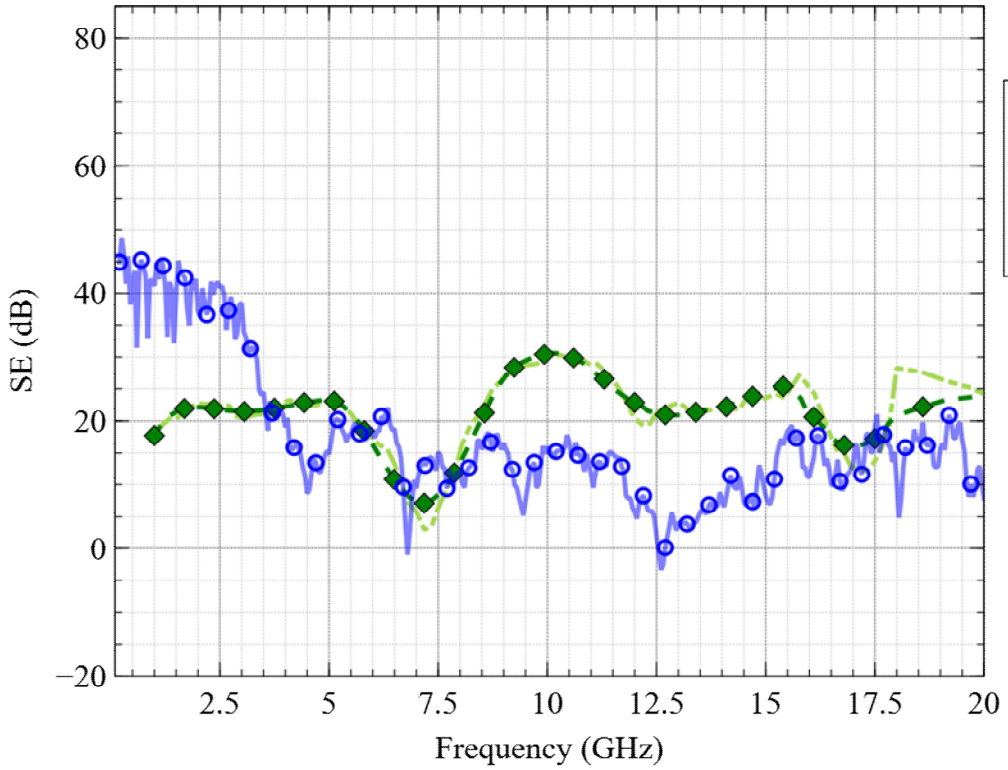
Laird:

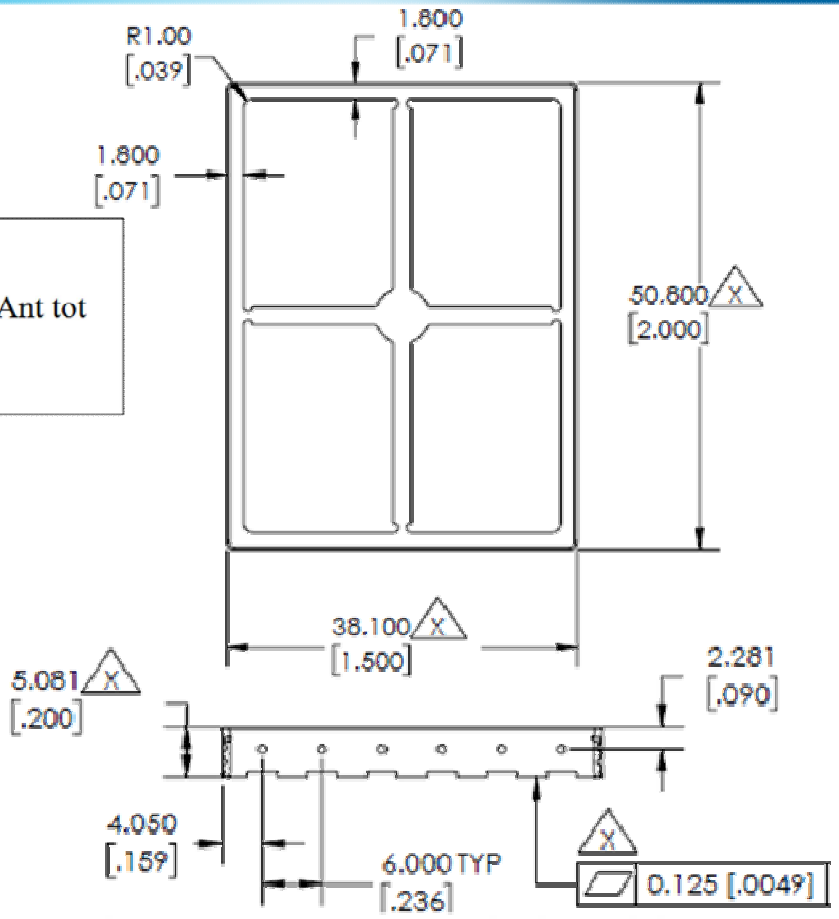
2.5m×2.5m×2.5m


Sample 1
Laird RC V2
UoY RC S2 Stir
SE (dB)
Frequency (GHz)
60
50
40
30
20
10
0
−10
0
10
20
30
40

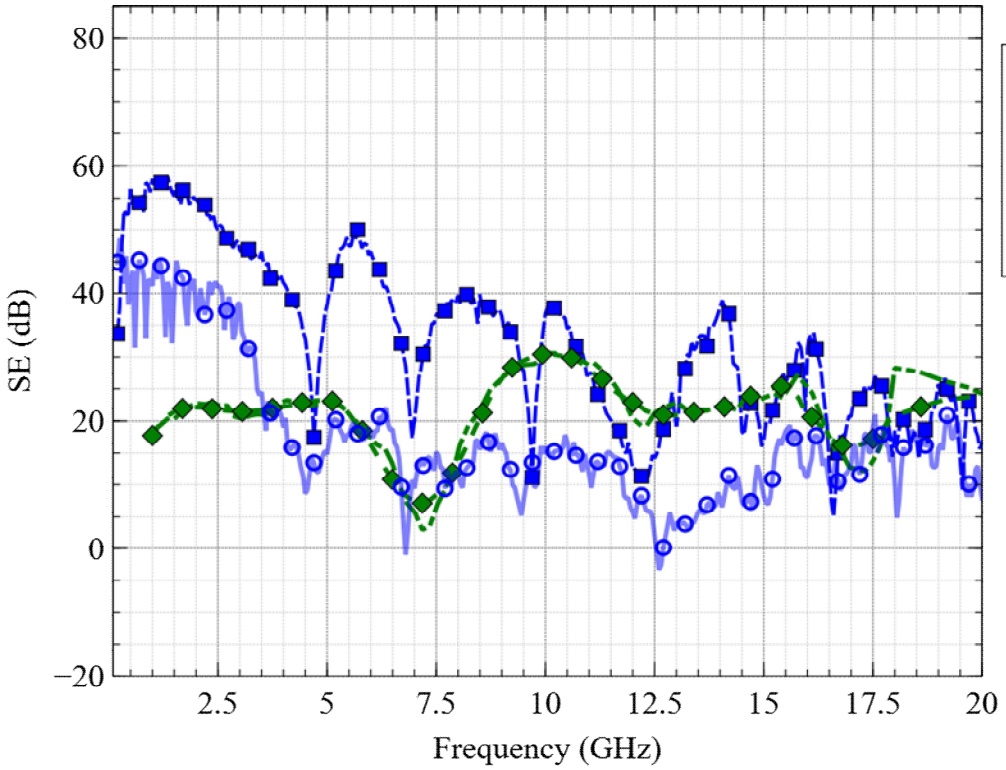

R0.85 TYP
[.033]
20.400
[.803]
0
[.000]
0
[.000]
38.400
[1.512]
Ø1.50 TYP
[.059]

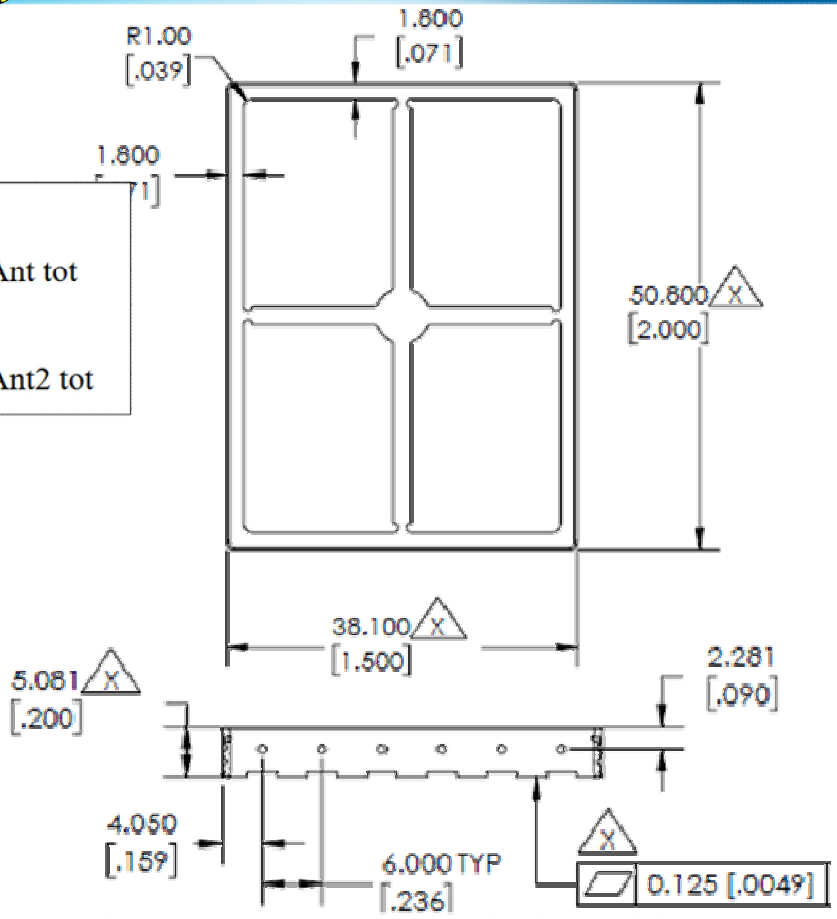
Initial measurements of Sample 2



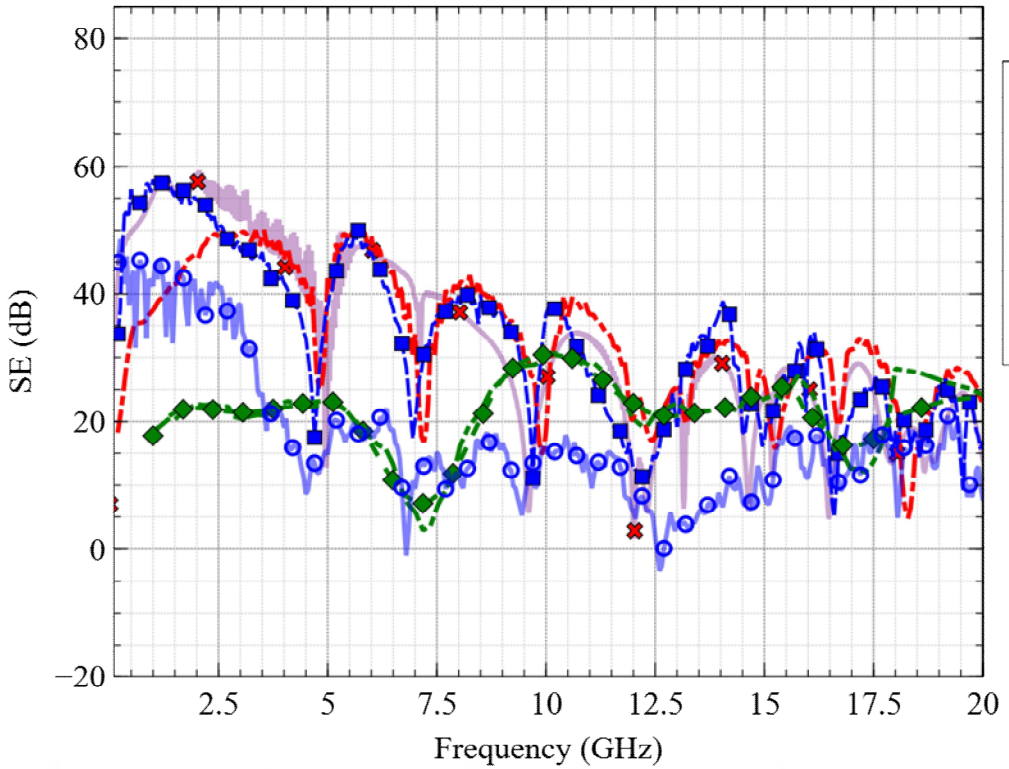


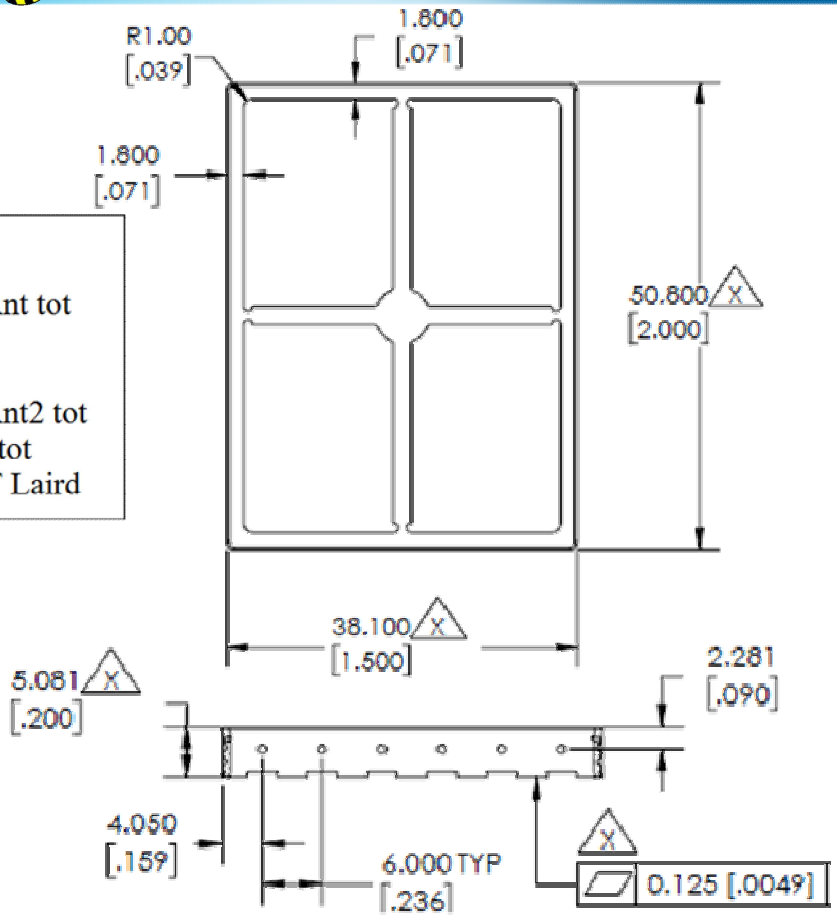
Adding UoY S3 measurement of Sample 2



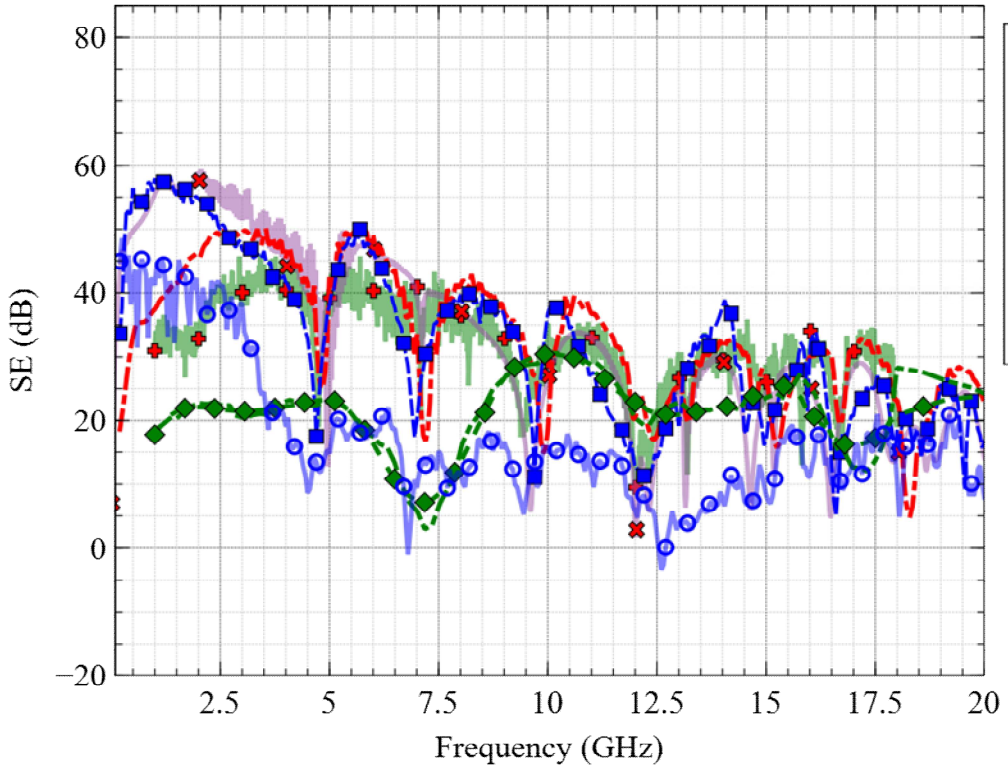


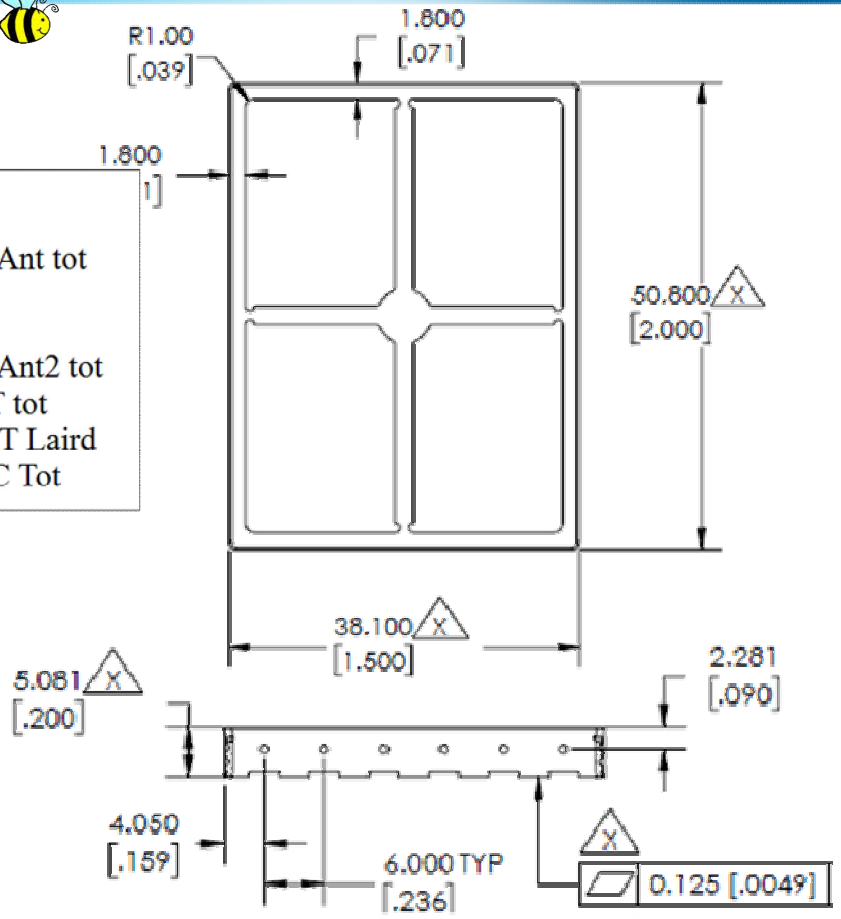
Now add UoY and Laird CST Models of Sample 2

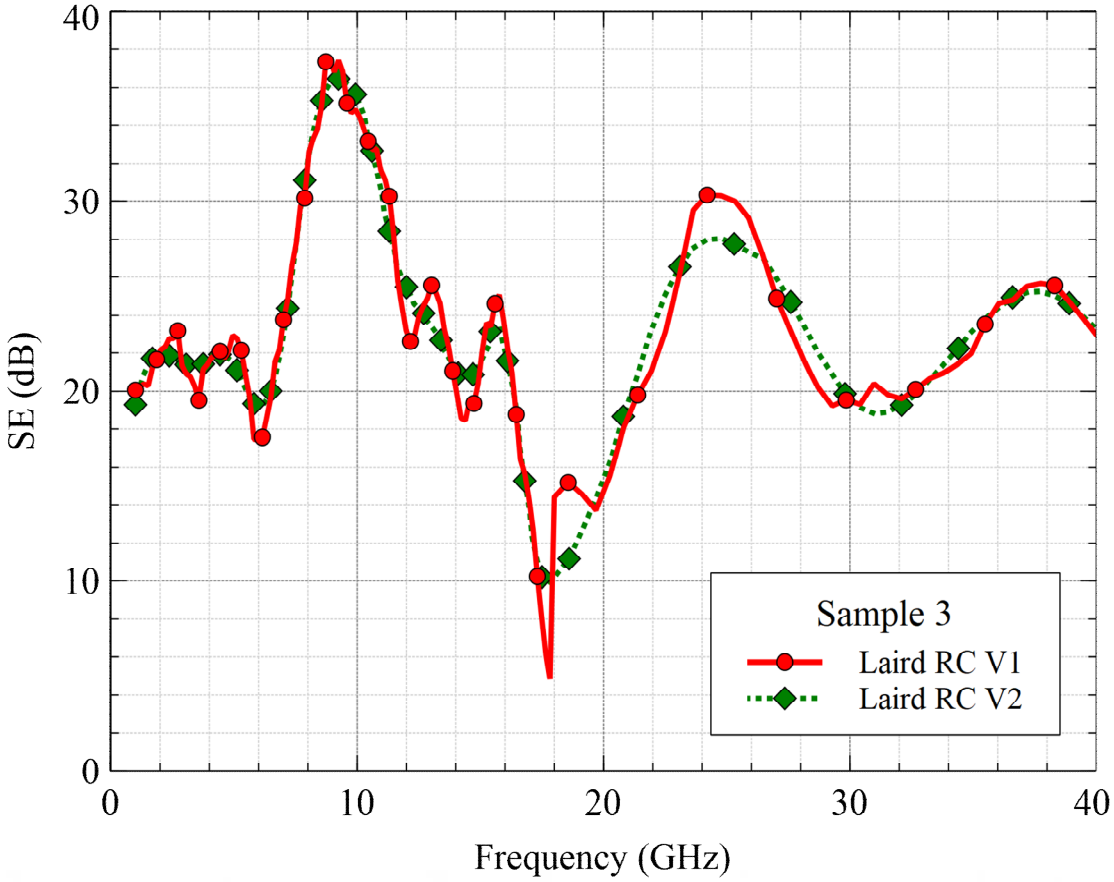


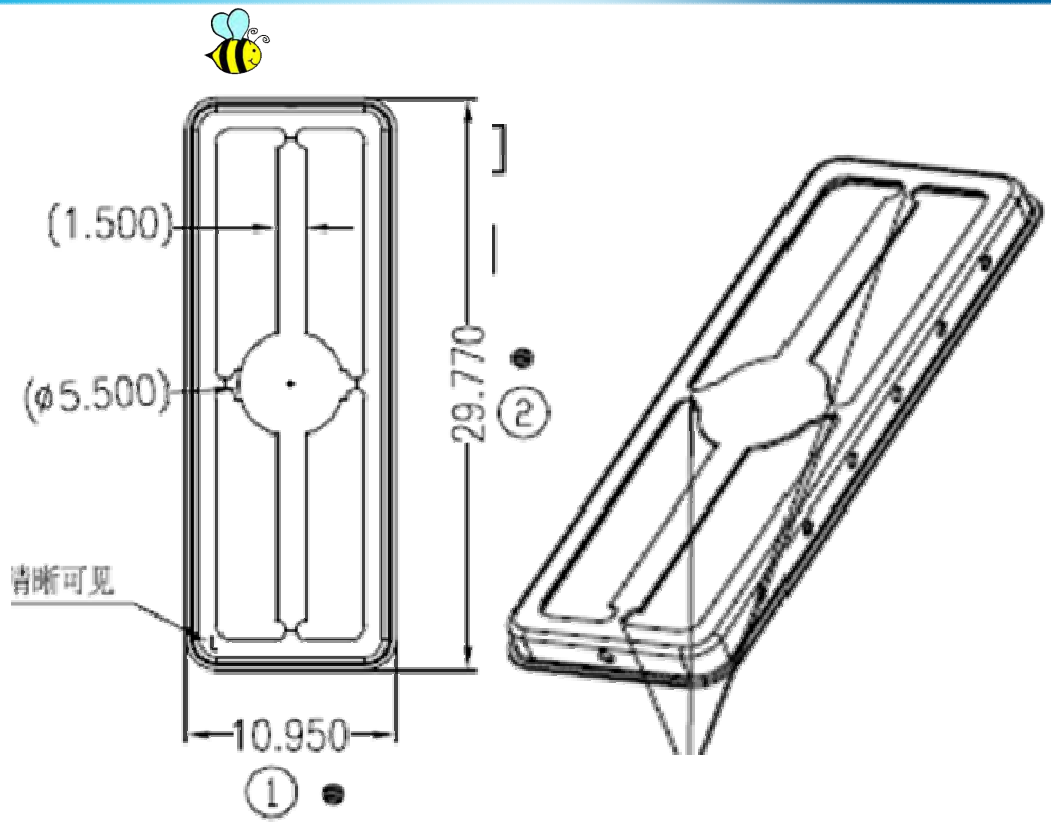


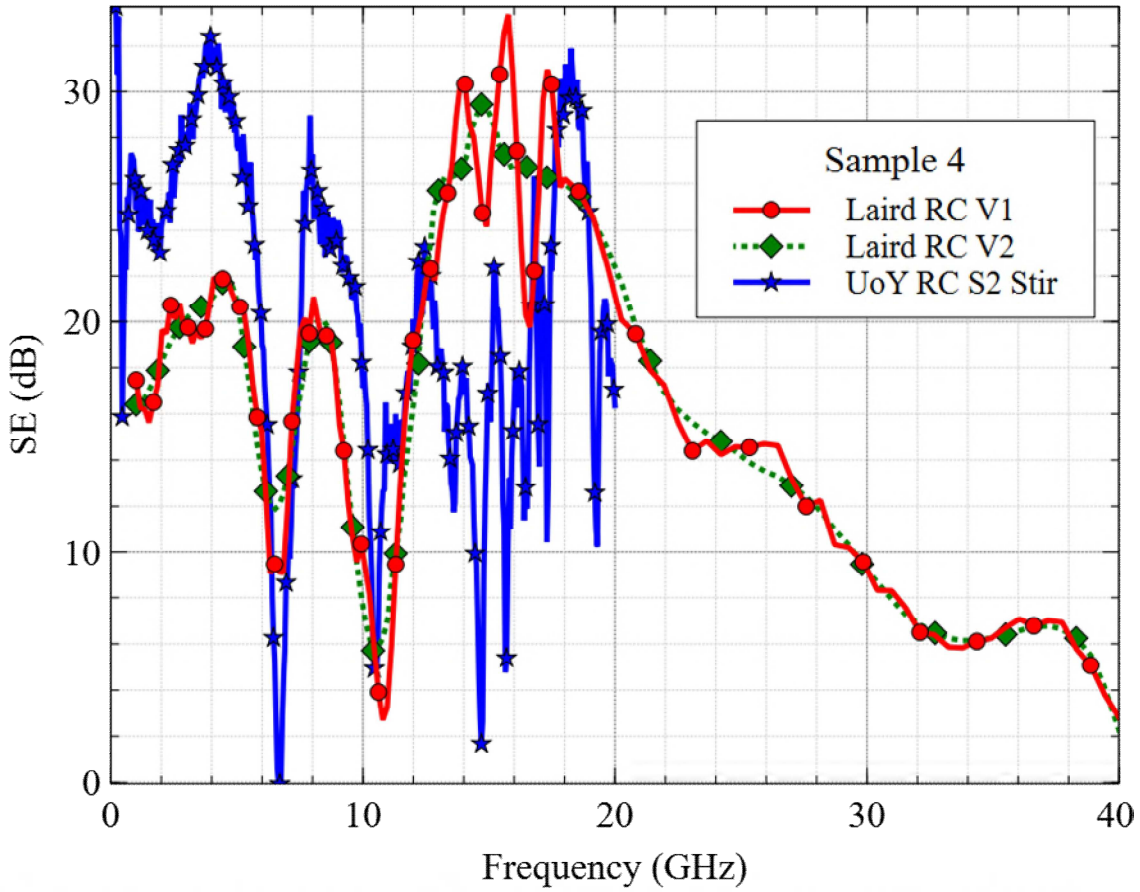
And finally Laird's V3 measurement of Sample 2

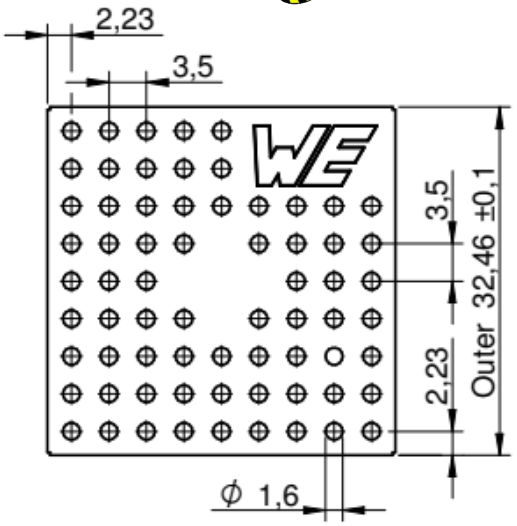


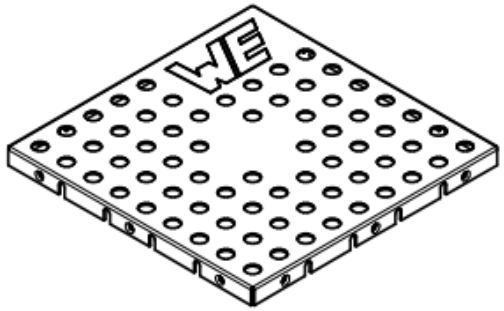


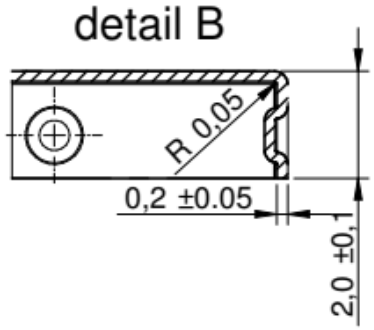

SE (dB)
Frequency (GHz)
0
10
20
30
40
Sample 3
Laird RC V1
Laird RC V2

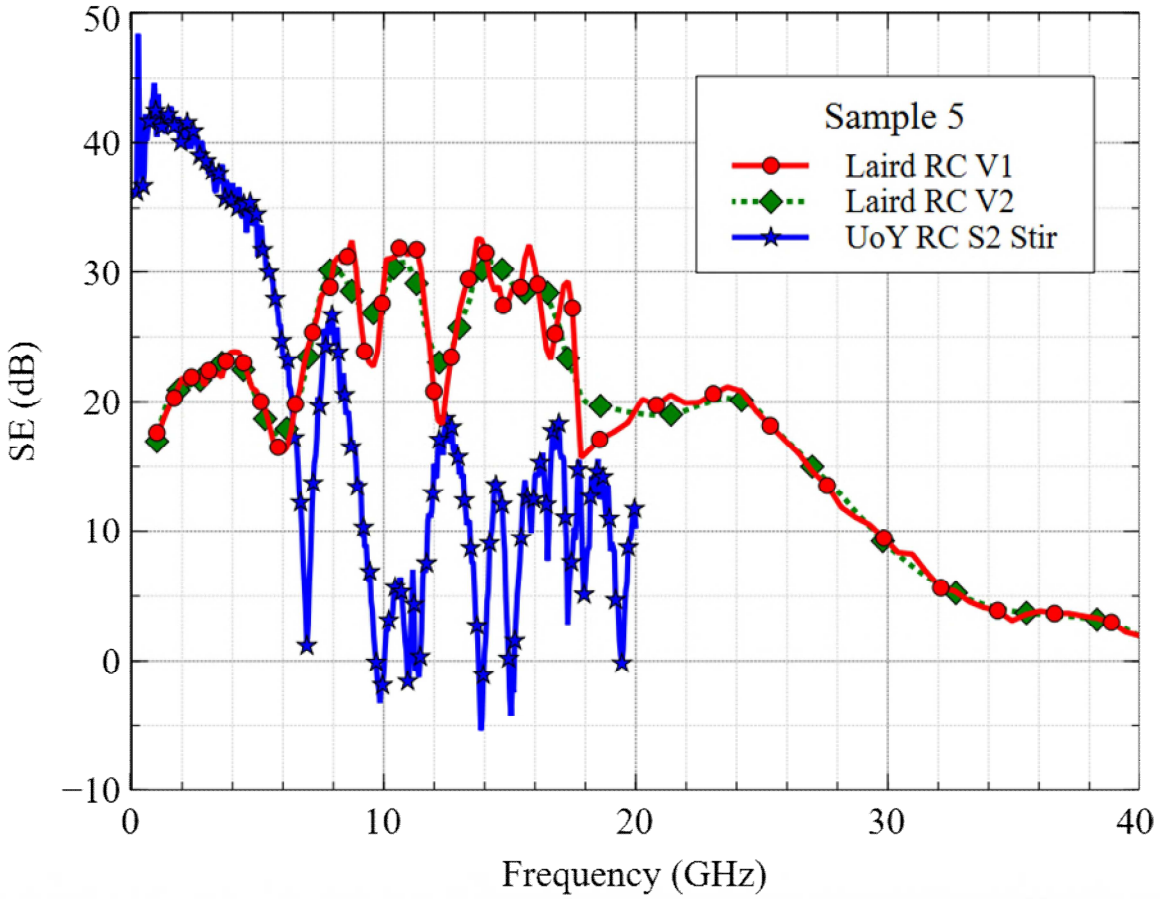

(1.500)
(ø5.500)
29.770
10.950
①
②

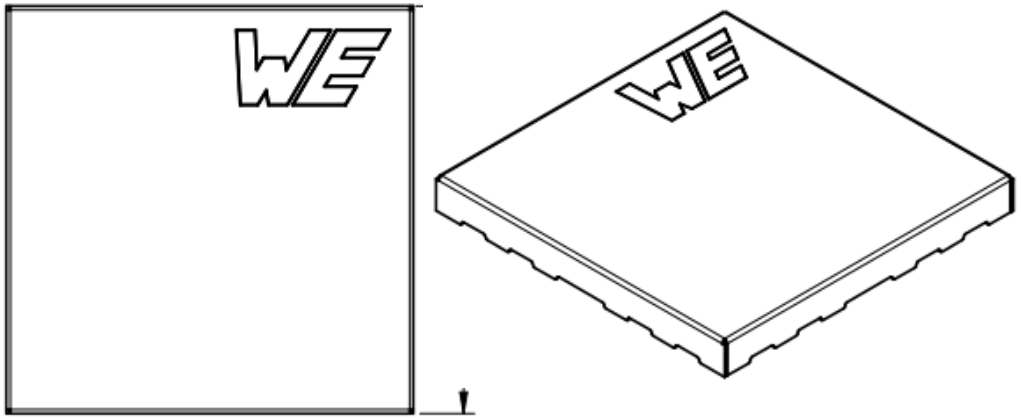

Sample 4
Laird RC V1
Laird RC V2
UoY RC S2 Stir
SE (dB)
Frequency (GHz)
0
10
20
30
40

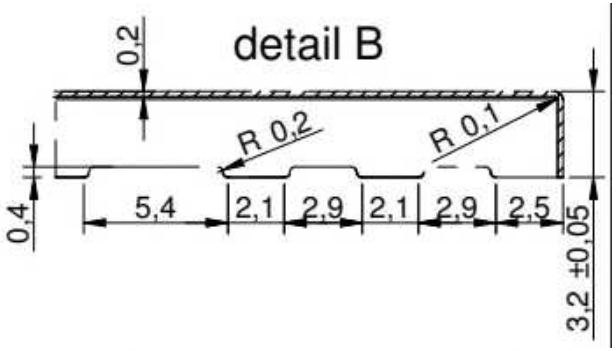

2,23
3,5
3,5
Outer 32,46 ±0,1
2,23
ϕ 1,6

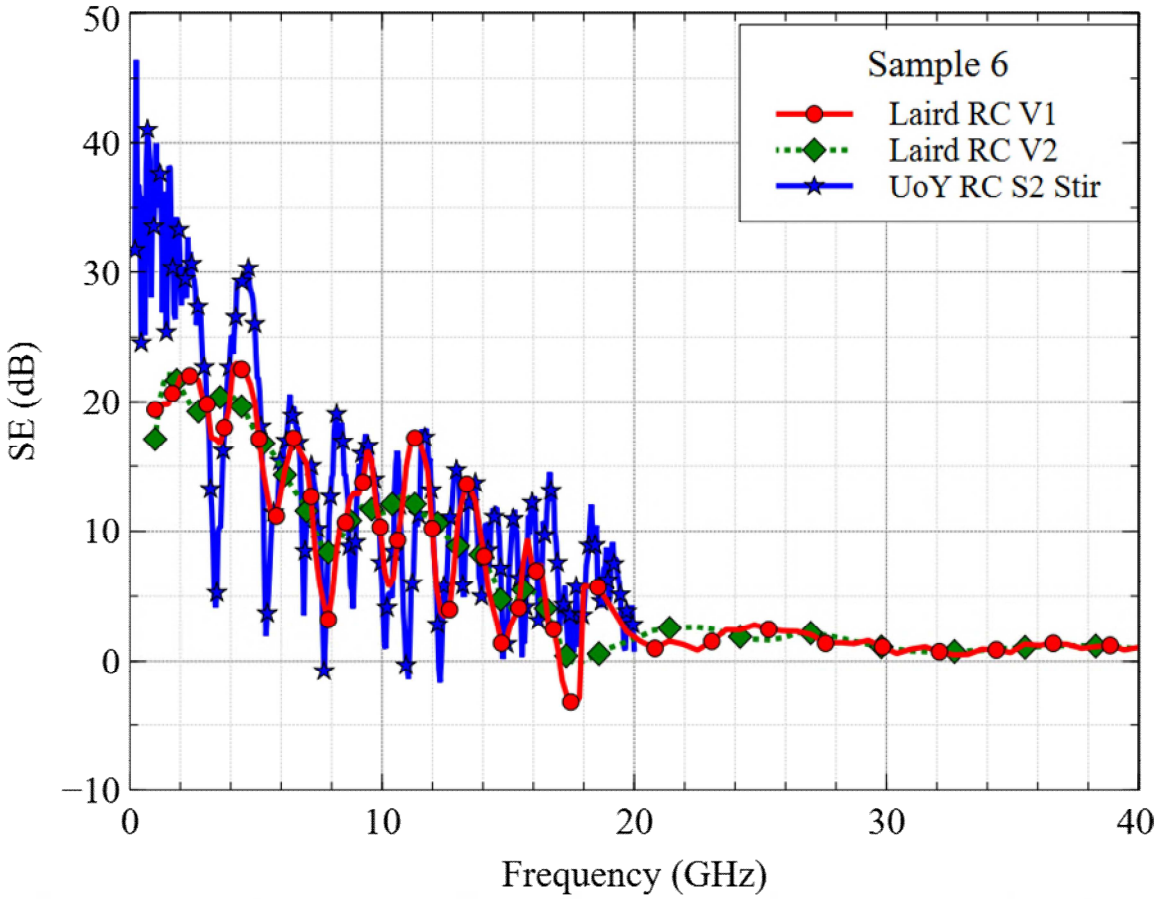


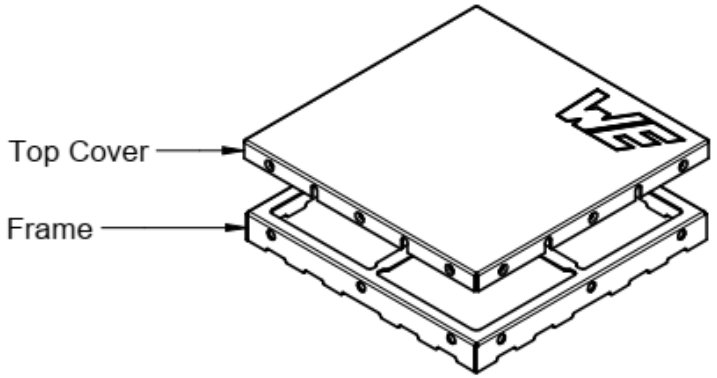

detail B
R 0,05
0,2 ±0.05
2,0 ±0,1

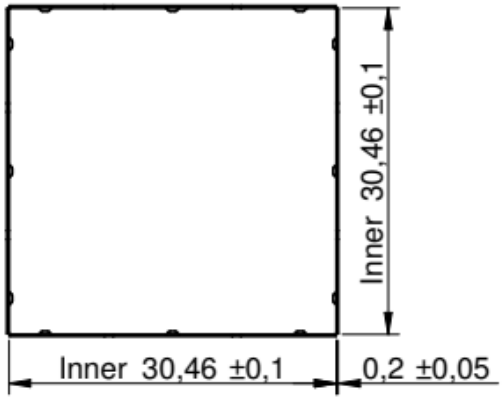

Sample 5
Laird RC V1
Laird RC V2
UoY RC S2 Stir
SE (dB)
Frequency (GHz)
50
40
30
20
10
0
−10
0
10
20
30
40

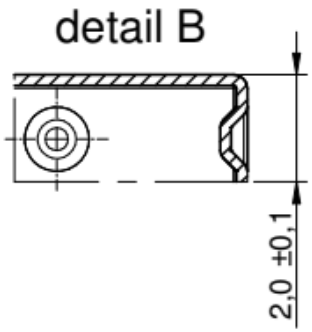

WE
WE

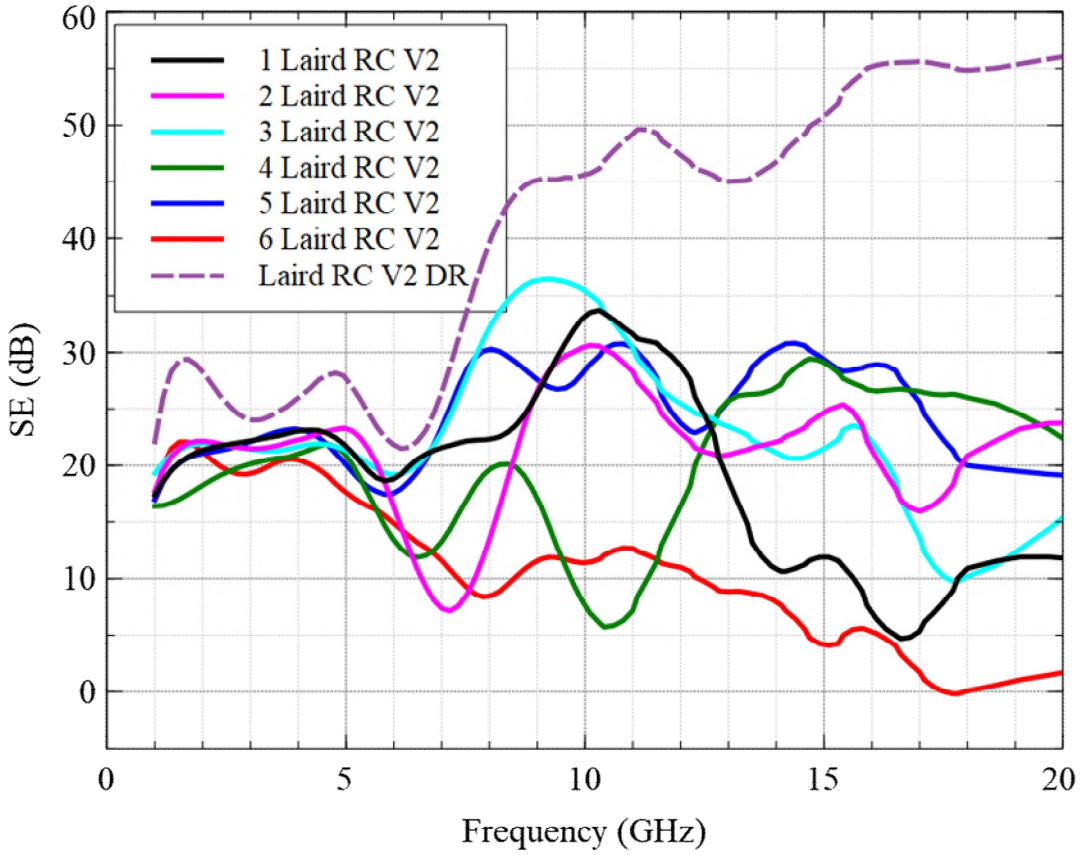

detail B
0,2
R 0,2
R 0,1
0,4
5,4
2,1
2,9
2,1
2,9
2,5
3,2 ±0,05

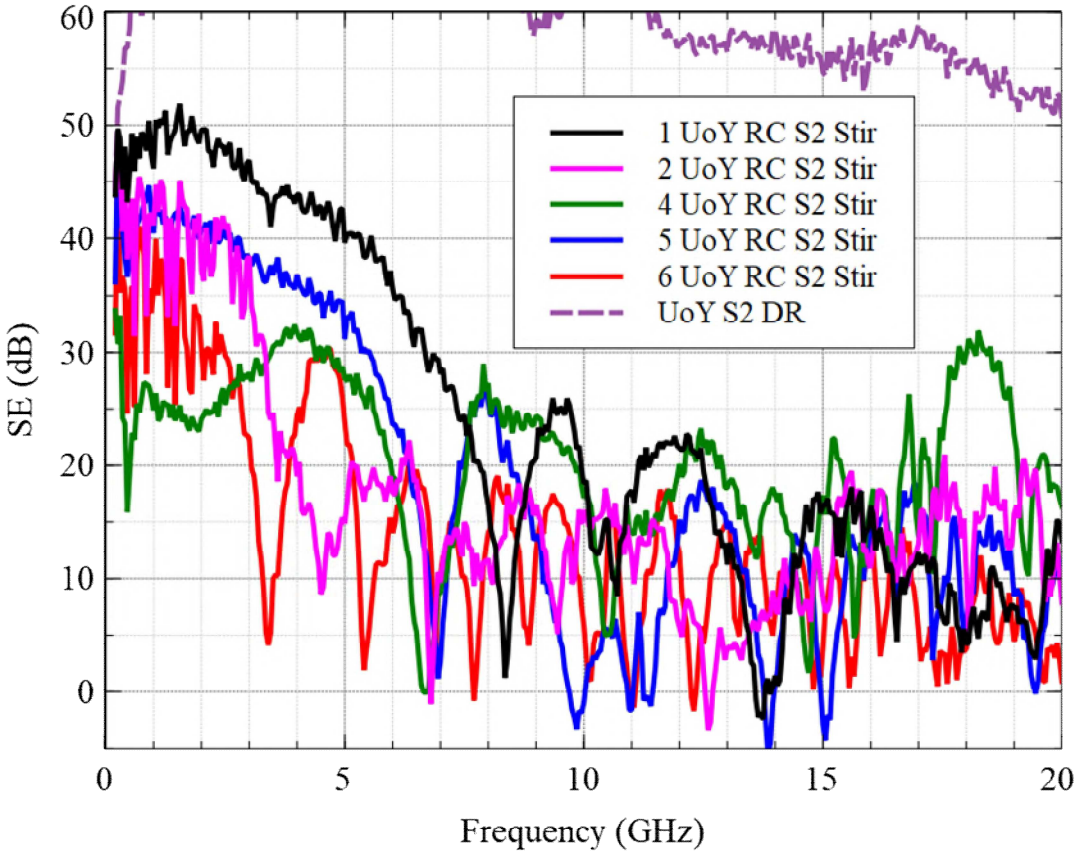

Sample 6
Laird RC V1
Laird RC V2
UoY RC S2 Stir
SE (dB)
Frequency (GHz)
50
40
30
20
10
0
−10
0
10
20
30
40


Top Cover
Frame


Inner 30,46 ±0,1
Inner 30,46 ±0,1
0,2 ±0,05


detail B
2,0 ±0,1


1 Laird RC V2
2 Laird RC V2
3 Laird RC V2
4 Laird RC V2
5 Laird RC V2
6 Laird RC V2
Laird RC V2 DR
SE (dB)
Frequency (GHz)
0
10
20
30
40
50
60
0
5
10
15
20


1 UoY RC S2 Stir
2 UoY RC S2 Stir
4 UoY RC S2 Stir
5 UoY RC S2 Stir
6 UoY RC S2 Stir
UoY S2 DR
SE (dB)
Frequency (GHz)
0
10
20
30
40
50
60
0
5
10
15
20

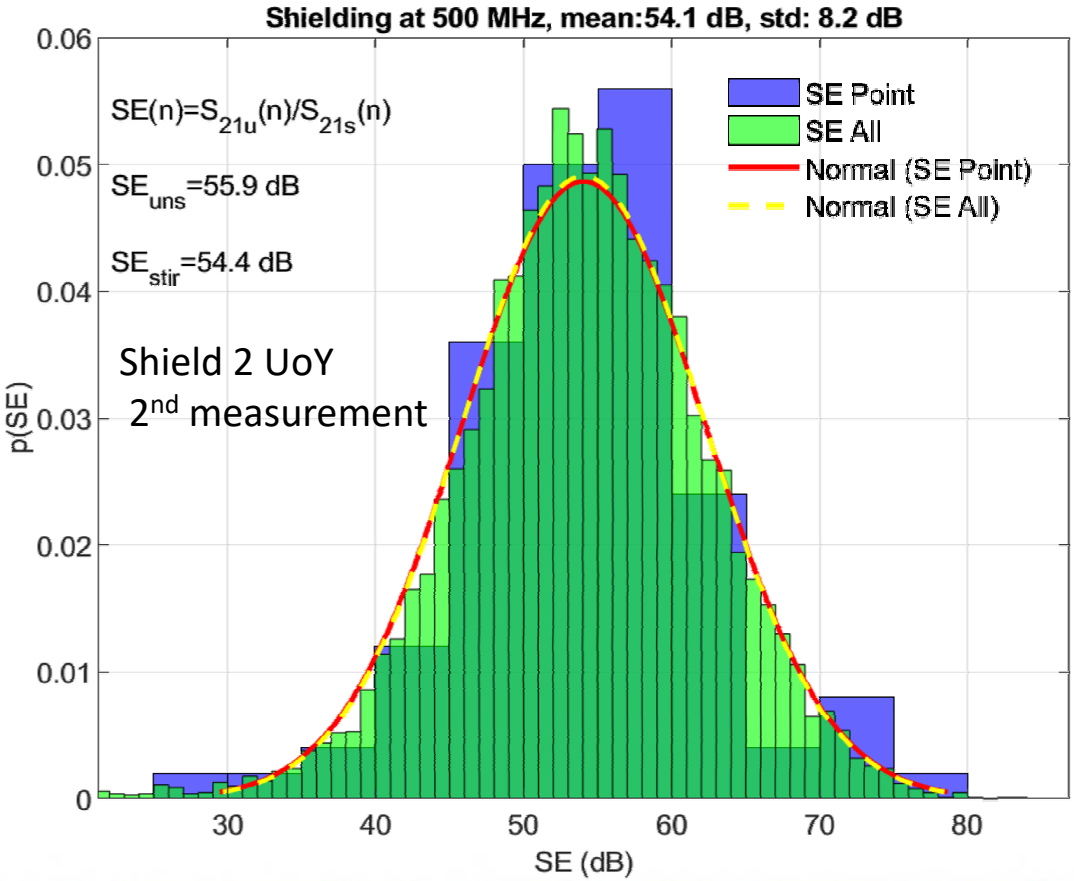
Statistics of SE

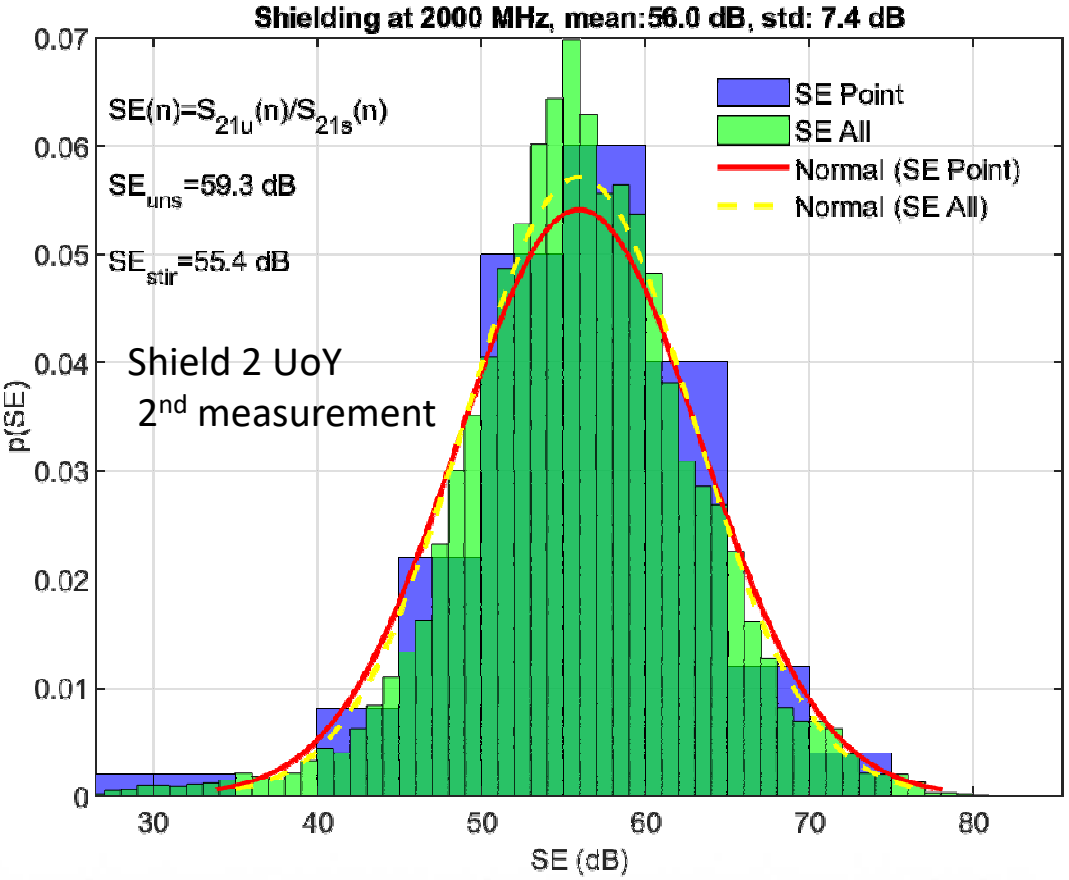
Usual definition of SE taking average of received power.

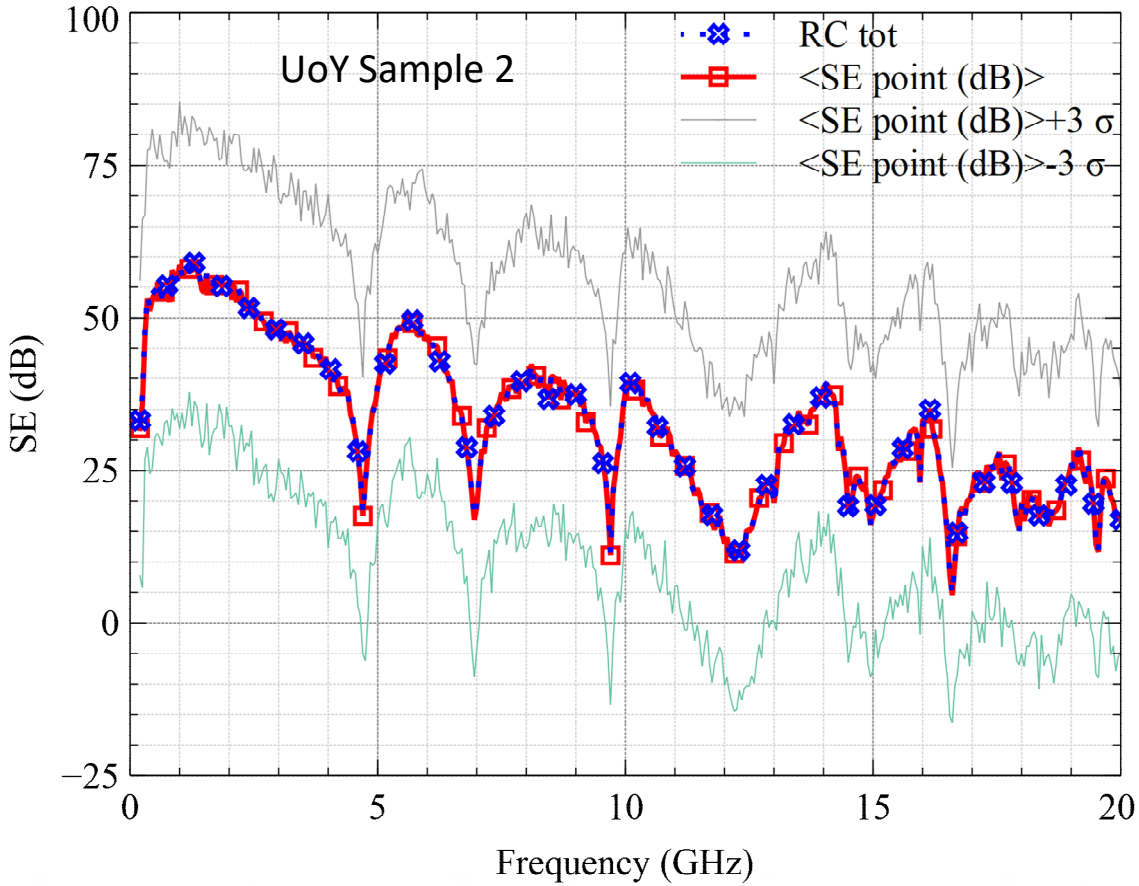
$$SE_{tot} = 10\log_{10}\left(\frac{\langle|S_{21u}|^2\rangle}{\langle|S_{21s}|^2\rangle}\right) \text{ dB}$$

The *Point SE* is the SE of the shield at each stirrer position with both direct and scattered energy included. This shows the range of variability of the SE that may be encountered in a range of external environments.

$$SE_{point(mean\ dB)} = \langle 10\log_{10}\left|\frac{S_{21u}}{S_{21s}}\right|^2\rangle \text{ dB}$$


Shielding at 500 MHz, mean:54.1 dB, std: 8.2 dB
SE(n)=S21u(n)/S21s(n)
SEuns=55.9 dB
SEstir=54.4 dB
Shield 2 UoY
2nd measurement
SE Point
SE All
Normal (SE Point)
Normal (SE All)
p(SE)
SE (dB)


Shielding at 2000 MHz, mean:56.0 dB, std: 7.4 dB
SE(n)=S21u(n)/S21s(n)
SEuns=59.3 dB
SEstir=55.4 dB
Shield 2 UoY
2nd measurement
SE Point
SE All
Normal (SE Point)
Normal (SE All)
p(SE)
SE (dB)



- $SE_{point(mean\ dB)}$ close to Std SE
- Standard deviation $\sigma \approx 8dB$
- So limits of SE variation
  - $\pm 3\sigma \approx \pm 24dB$
- In taking a mean we sometimes lose sight of reality….
- See also
  - 10.1109/EMCEUROPE48519.2020.9245741
  - and
  - "Experimental Verification of Board Level Shielding Variability at Microwave Frequencies"

Final Remarks

- Single reverb method is closest to real use
  - BUT contents still not the same as in real use which may affect result
- Measurements to date show significant difference between slightly different jigs
- Is this jig geometry or measurement/jig fault ?
  - Re-test and modelling of shield 2
  - Modelling suggests jig/measurement problem with initial measurements
  - Repeat measurements and modelling correspond more closely
- Further investigation ongoing